

LADEE Preparations for Contingency Operations for the Lunar Orbit Insertion Maneuver

Abstract

The Lunar Atmosphere and Dust Environment Explorer (LADEE) spacecraft was launched on September 6, 2013, and completed its mission on April 17, 2014 with a directed impact to the Lunar Surface. Its primary goals were to examine the lunar atmosphere, measure lunar dust, and to demonstrate high rate laser communications. The LADEE mission was a resounding success, achieving all mission objectives, much of which can be attributed to careful planning and preparation. This paper discusses the specific preparations for fault conditions that could occur during a highly-critical phase of the mission.

To get to the Moon, the spacecraft traversed multiple phasing loops around the Earth, and then executed a breaking maneuver to achieve lunar orbit. This Lunar Orbit Insertion (LOI) maneuver was perhaps the most time-critical phase of the entire mission. The LOI maneuver had to occur within a twenty minute window in order to achieve lunar orbit with an acceptable amount of propellant remaining. Missing this window would have likely resulted in a loss of the entire mission. An additional challenge of the maneuver was that spacecraft was out of view for approximately one hour prior to the main thruster burn, with the burn needing to occur within five minutes after coming into view. These conditions resulted in unique challenges for ground operations and the fault management system.

Early in the planning stages of the mission, the criticality and challenges of this maneuver were evident to the system designers. The major concern was that any triggering of the on-board fault management system, whether it is in response to a true fault or a false positive, would result in an unacceptable delay to the burn. Therefore the flight software was designed with a flexible fault management system, such that any or all of the fault management responses could be disabled for the lead up and execution of the maneuver. Later, a triage was conducted to develop a list of fault responses, mapped to various parts of the timeline of the maneuver. Some of these contingency responses were solely ground-based if the time to detect, diagnose, and respond were adequate. Other responses were automated on-board if the response time from the ground would have been inadequate. For instance, in order to recover from a system reboot, on-board automation would have automatically reconfigured the spacecraft for the burn and reoriented the spacecraft to the burn attitude.

These contingency responses were practiced, over and over, during numerous rehearsals. Although the LOI maneuver was executed without having to use any of these contingencies, the LADEE team was adequately prepared for this highly critical phase of the mission.